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PERFORMANCE EVALUATION OF FEED AND RECYCLE GAS CHILLER INFLUENCE ON ENVIRONMENTAL CONDITIONS IN THE PRODUCTION PROCESS PLANT

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ABSTRACT

Heat transfer by convection is strongly influenced by the geometric shapes of heat exchangers and three dimensionless number, the Reynolds number, Nusselt number and Prandtl number with the environmental conditions of the surrounding air. Any environmental influences cause actual results and theoretical conditions differ. This is one of the problems at the plant in the production process results, especially the heat exchanger type of chiller. In this paper aims to determine the impact of the ammonia production process of the influence of changing environmental conditions and to apply the concept of heat and mass transfer in the Chiller as knowledge development models ammonia optimum production equipment in the ammonia. In this study, measurements were performed during the morning, afternoon, evening, and night on normal weather and rain by using thermo-anemometer and thermo-hygrometer. The results showed an increase in heat during heavy rains and decrease the heat when the normal environmental conditions. With the highest increase in the heat on the morning of 14 July 2015 where the air temperature was recorded at 26.3 °C, the speed of 6.79 m / s, the air flow rate of 19 688 Watt heat and mass flow rate of the ammonia evaporates increased 49.797 kg / h to with 50.368 kg / h. Mass flow rate that evaporates due to the heat transfer air is not decreased by more than 1% despite the chiller effectiveness decreased from 90.422% to 61.259% due to boundary conditions which allowed fouling factor.

Keywords: Environmental condition, Overal heat transfer coefficient, Heat rate, Ammonia Production Proces

1. INTRODUCTION

The energy crisis is an issue in recent years. Different solutions and alternatives have been offered by experts, in the form of of energy development tools, the use of alternative energy, or the energy conservation. The problem will not be resolved if the people, government and industry use energy inefficiently. One concept for improve the efficiency of the thermal system is to analyze the condition of the environment in apparatus which means analyzing energy in total dimensions of the device itself.

In Indonesia, climate change becomes worthy of analysis, changes in environmental conditions over time can make the temperature and velocity of air in the environment is different, it is an important consideration in determining the strategy in the field of industry sectors where the incidence of weather changes affect production industries, especially the energy sector. If seen the impact of the predicted climate elements especially rainfall very calculated. In the end it will make the heat duty was different so there must be a control that occur as a function of the quality of the company's production directorate. In the purification plant in the sector is the sector that has the greatest energy costs primarily as a means of producing ammonia chiller, but because the chiller is in the classification of the synthesis loop chiller also includes refrigeration sector and serves as a heater ammonia as raw material for the manufacture of urea. The analysis result is closer to the actual outcome is the result of calculations involving geometry-geometry air chiller and environmental conditions than just the zero-dimensional thermodynamic calculations, and it is also very helpful menjalalankan targeted optimization of plant processes in energy saving measures in producing ammonia and urea.

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The purpose of this research was to determine the effects of ammonia production process of the influence differences in environmental conditions and to apply concepts the heat transfer and mass Chiller as a development model that optimum ammonia production apparatus at the ammonia plant.

2. METODOLOGY

This research was conducted by using a thermo-anemometer to measure the temperature and air velocity around the shell of the chiller. Retrieval of data measurements taken 4 times a day do in the morning, noon, afternoon, and evening.

The flow chart of thist research is folow

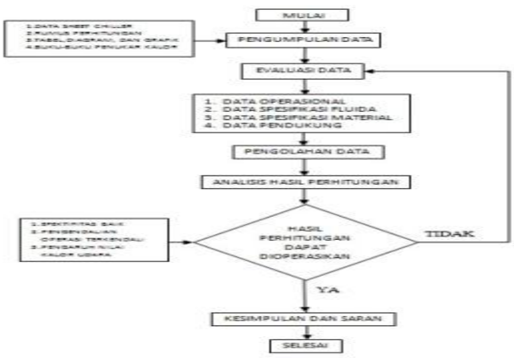

Figure 1. Flowchart of Research

Measurement Temperature and Air Speed aims to obtain data values environment condition such as temperature and air velocity value.

Figure 2. Termo-Anemometer

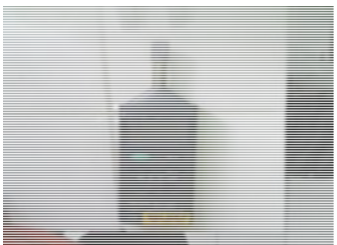

Figure 3. Termo-Hygrometer

Measurement of the temperature value is the average value of each corner taken accompanied by the use of two tools to measure the temperature of which thermo-anemometer and thermo-hygroanemometer, while the measurement using only air keceparan thermo-anemometer.

3. RESULT AND DISCUSSION

On the results of analysis, geometry calculations through consideration of shell and tube chiller when clean the heat transfer coefficient values obtained air and heat flow rate of air.

Table 5. The results of calculation of heat flow rate of air around at week 1

Tanggal	waktu	T_a (°C)	V (m/s)	h_c (w/m².K)	$\dot{Q}_c$ (W)	$\dot{Q}_o$ (W)
02-Jul-15	08.15	30,1	0,51	2,439335714	3369,3045	3363,103
	11.44	35,3	0,65	2,820130949	4215,43777	4206,472
	16.13	31,6	0,93	3,562541413	5034,73139	5021,216
	19.13	28,4	2,54	7,154986865	9592,79173	9541,31
03-Jul-15	08.12	30,6	0,51	2,438031363	3394,18906	3387,945
	14.03	35,2	0,68	2,901731548	4330,876	4321,399
	16.47	32,6	0,82	3,279317706	4706,90683	4695,272
	19.02	29,1	1,91	5,825964029	7905,4924	7870,888

Table 6. The results of calculation of heat flow rate of air around at week -2

Tanggal	waktu	T_a (°C)	V (m/s)	h_c (w/m².K)	$\dot{Q}_c$ (W)	$\dot{Q}_o$ (W)
06-Jul-15	08.20	29,8	0,51	2,440168421	3354,42886	3348,252
	11.39	35,7	0,57	2,597152777	3905,32931	3897,677
	16.27	30,2	0,84	3,340914988	4619,73181	4608,099
	19.09	28,6	1,98	5,981398235	8050,40368	8014,232
07-Jul-15	08.12	29,2	0,51	2,441846783	3324,6624	3318,536
	11.37	35,5	0,62	2,737285955	4103,76316	4095,29
	16.17	31,9	1,03	3,807876343	5405,74581	5390,24
	19.21	28,3	2,05	5,984084977	8014,78441	7978,757
08-Jul-15	08.38	29,6	0,53	2,499397179	3424,80046	3418,342
	14.09	30,4	4,68	11,27814632	15579,7345	15448,63
	17.01	31,4	0,73	3,048726629	4296,4035	4286,527
	18.59	24,2	6,86	15,44532429	19208,0579	18987,85
09-Jul-15	08.11	30,3	0,54	2,526380752	3500,43518	3493,763
	11.53	36,1	0,43	2,184870242	3305,22419	3299,773
	16.13	31,7	0,61	2,721117613	3853,24675	3845,338
	19.09	23,4	7,6	16,97518145	20798,8041	20537,24
10-Jul-15	08.37	30,4	0,53	2,497129095	3465,42444	3458,895
	14.07	35,3	0,47	2,307700215	3450,39942	3444,39
	17.04	32,5	0,58	2,634443338	3776,80972	3769,304
	19.24	28,9	2,34	6,736228288	9106,8943	9060,856

Table 7. The results of calculation of heat flow rate of air around at week -3

Tanggal	waktu	T_a (°C)	V (m/s)	h_c (w/m².K)	$\dot{Q}_c$ (W)	$\dot{Q}_o$ (W)
13-Jul-15	08.13	28,4	3,43	8,93441533	11967,3685	11887,35
	11.32	35,1	0,36	1,965732498	2931,01891	2926,669
	03.19	31,1	0,76	3,12925112	4389,15423	4378,799
	07.02	28,6	2,38	6,822864622	9178,90026	9131,906
14-Jul-15	08.11	26,3	6,79	15,26991062	19688,8896	19465,68
	11.31	33,6	0,43	2,190137321	3193,31383	3188,035
	16.33	30,4	0,82	3,288540112	4561,82449	4550,517
	19.23	28,1	1,7	5,378284034	7182,17782	7153,139
15-Jul-15	08.02	29,6	0,64	2,81127806	3851,52618	19468,49
	11.57	35,3	0,66	2,847319738	4256,01806	4246,879
	16.33	28,4	4,45	10,89296865	14575,8849	14457,36
	19.05	29,1	1,91	5,825964029	7905,4924	7870,888

Table 8. The results of calculation of heat flow rate of air around at week -4

Tanggal	waktu	T_a (°C)	V (m/s)	h_a (w/m².K)	$\dot{Q}_C$ (W)	$\dot{Q}_D$ (W)
22-Jul-15	08.04	30,3	0,44	2,22831706	3087,93419	3082,741
	11.44	35,2	0,83	3,294601446	4916,22841	4904,02
	16.05	31,4	0,67	2,887388239	4069,38196	4060,521
	19.02	28,1	1,43	4,772849505	6375,69761	6352,804
23-Jul-15	08.12	30,8	0,42	2,165244811	3024,33139	3019,388
	11.51	35,8	0,53	2,484512631	3741,61156	3734,597
	16.24	32,7	0,51	2,407354902	3462,19955	3455,91
	19.08	28,2	0,98	3,702626883	4956,93686	4943,11
24-Jul-15	08.21	30,2	0,42	2,166967864	2998,27075	2993,366
	01.59	35,6	0,39	2,061128566	3095,66945	3090,852
	16.27	31,9	0,56	2,579389983	3664,11565	3656,985
	19.09	28,6	1,32	4,516123388	6082,9411	6062,266

the rate of heat flow that vary each time it can result in mass flow rate calculation analysis of ammonia as a working fluid is evaporated additional shell.

Table 9. mass flow rate calculation results of the additional ammonia evaporated by week - 1

Tanggal	waktu	T_a (°C)	V (m/s)	h_a (w/m².K)	$\dot{m}_C$ (kg/jam)	$\dot{m}_D$ (kg/jam)
02-Jul-15	08.15	30,1	0,51	2,439335714	8,61941276	8,603547048
	11.44	35,3	0,65	2,820130949	10,7840054	10,76106781
	16.13	31,6	0,93	3,562541413	12,8799365	12,84536156
	19.13	28,4	2,54	7,154986865	24,5404449	24,40874264
03-Jul-15	08.12	30,6	0,51	2,438031363	8,68307286	8,667098494
	14.03	35,2	0,68	2,901731548	11,0793215	11,05507639
	16.47	32,6	0,82	3,279317706	12,04129	12,01152538
	19.02	29,1	1,91	5,825964029	20,2239667	20,13544096

Table 10. mass flow rate calculation results of the additional ammonia evaporated by week - 2

Tanggal	waktu	T_a (°C)	V (m/s)	h_a (w/m².K)	$\dot{m}_C$ (kg/jam)	$\dot{m}_D$ (kg/jam)
06-Jul-15	08.20	29,8	0,51	2,440168421	8,58135763	8,56555659
	11.39	35,7	0,57	2,597152777	9,99068063	9,971105027
	16.27	30,2	0,84	3,340914988	11,8182774	11,78851761
	19.09	28,6	1,98	5,981398235	20,5946812	20,50214595
07-Jul-15	08.12	29,2	0,51	2,441846783	8,50520857	8,489537012
	11.37	35,5	0,62	2,737285955	10,4983175	10,47664126
	16.17	31,9	1,03	3,807876343	13,8290719	13,78940511
	19.21	28,3	2,05	5,984084977	20,5035594	20,41139246
08-Jul-15	08.38	29,6	0,53	2,499397179	8,76138347	8,744860624
	14.09	30,4	4,68	11,27814632	39,8563449	39,52094019
	17.01	31,4	0,73	3,048726629	10,9911334	10,96586754
	18.59	24,2	6,86	15,44532429	49,1383843	48,57504287
09-Jul-15	08.11	30,3	0,54	2,526380752	8,95487351	8,937804032
	11.53	36,1	0,43	2,184870242	8,4554814	8,441536501
	16.13	31,7	0,61	2,721117613	9,85744213	9,837208884
	19.09	23,4	7,6	16,97518145	53,2078585	52,53872945
10-Jul-15	08.37	30,4	0,53	2,497129096	8,86530842	8,848604708
	14.07	35,3	0,47	2,307700215	8,82687117	8,811497789
	17.04	32,5	0,58	2,634443338	9,66189961	9,642697308
	19.24	28,9	2,34	6,736228288	23,2974137	23,17963755

Table 11. mass flow rate calculation results of the additional ammonia evaporated by week - 3

Tanggal	waktu	T_a (°C)	V (m/s)	h_a (w/m².K)	$\dot{m}_C$ (kg/jam)	$\dot{m}_D$ (kg/jam)
13-Jul-15	08.13	28,4	3,43	8,93441533	30,6151279	30,41042512
	11.32	35,1	0,36	1,965732498	7,49818301	7,487054078
	03.19	31,1	0,76	3,12925112	11,2284099	11,20191962
	07.02	28,6	2,38	6,822864622	23,4816206	23,36139971
14-Jul-15	08.11	26,3	6,79	15,26991062	50,3684563	49,79744506
	11.31	33,6	0,43	2,190137321	8,1691904	8,155685263
	16.33	30,4	0,82	3,288540112	11,6701379	11,64120991
	19.23	28,1	1,7	5,378284034	18,3735709	18,29928264
15-Jul-15	08.02	29,6	0,64	2,81127806	9,85304054	49,8046301
	11.57	35,3	0,66	2,847319738	10,8878186	10,86443773
	16.33	28,4	4,45	10,89296865	37,2882796	36,98505537
	19.05	29,1	1,91	5,825964029	20,2239667	20,13544096

Table 12. mass flow rate calculation results of the additional ammonia evaporated by week - 4

Tanggal	waktu	T_a (°C)	V (m/s)	h_a (w/m².K)	$\dot{m}_C$ (kg/jam)	$\dot{m}_D$ (kg/jam)
22-Jul-15	08.04	30,3	0,44	2,22831706	7,89960637	7,886319893
	11.44	35,2	0,83	3,294601446	12,5767801	12,5455475
	16.05	31,4	0,67	2,887388239	10,410363	10,38769394
	19.02	28,1	1,43	4,772849505	16,3104193	16,25185134
23-Jul-15	08.12	30,8	0,42	2,165244811	7,73689659	7,724251088
	11.51	35,8	0,53	2,484512631	9,57185506	9,553910931
	16.24	32,7	0,51	2,407354902	8,85705845	8,840968393
	19.08	28,2	0,98	3,702626883	12,6809212	12,64554828
24-Jul-15	08.21	30,2	0,42	2,166967864	7,67022783	7,657681348
	01.59	35,6	0,39	2,061128566	7,91939485	7,907071824
	16.27	31,9	0,56	2,579389983	9,3736037	9,355362384
	19.09	28,6	1,32	4,516123388	15,5614846	15,50859424

The interaction of environmental conditions on the surface shell on the chiller is characterized by the distribution of the heat transfer coefficient of the surrounding air. In the measurement results obtained ambient air temperature and air velocity varied thus obtained is also the result of heat transfer coefficient different air. There is also the heat transfer coefficient was varied measured on 2 July to 24 July 2015 lowest to highest values obtained ranged from 1.965 W/m2.K up to 16.975 W/m2.K. At the lowest heat transfer coefficient obtained on July 13, 2015 at 11:45 pm, with the measurement temperature of 35.1 °C and speed of 0.36 m / s, then the highest heat transfer coefficients obtained on July 9, 2015 hrs with a temperature of 23.4 °C and the average air speed 7,60 m/s.

The temperature difference is its condition occurs heat transfer, fluid temperatures known ammonia in the shell turned out to be lower than the temperature in the environment yan, a result of it, the air will release the heat to the surface of the wall of the shell on the chiller. By knowing the value of the coefficient of heat transfer, and analyzing the convection and conduction equation, it can determine the calorific value of ammonia adsorbed fluid on the shell side. Any changes in environmental conditions that constantly will make the value of heat flow rate will change with the value of heat transfer coefficient of air. The greater the heat transfer coefficient, it will cause the flow rate of heat that moves will be even greater. Chiller 3A-119C has a state of the process according to the design of clean and dirty fouling factor permissible limits, the longer the unknown value of ammonia transfer coefficient will decrease due to the growing resistance values caused fouling resistance values. Therefore, the change will affect an estimated calorific value decreases. The coefficient of heat transfer of ammonia in a clean state is 3315.5 W /

m2.K and the coefficient of heat transfer time limit fouling factor is 957.9 W/ m2.K. Having taken into account as a result turns the air calorific value changes decreased only very few such examples dated July 2, beginning at the time of tube chiller heat clean is 3369.103 W/m2.K and dirty is 3363.103 W/m2.K, this shows the influence of heat air remained stable even though the value of the effectiveness of the chiller is decreased when reaching fakor fouling the heat transfer between the synthesis gas and ammonia.

The measurement results are varied during the study showed differences in temperatures ranging from 23.4 ℃ to 36.1 ℃ with each day, the difference in temperature in the morning, afternoon, evening, and night does not ensure that the highest calorific value of flow rate during the day or at the highest temperature. Results recorded the highest value of the rate of heat more dominant accompanied by ambient air velocity average high. On 09 July 2015 the measured value of the lowest temperature at night (23.4 ℃) and highest during the day (36.1 ℃), but in the evening the air velocity is higher with very heavy rain so that the flow rate of heat turns worth 20798.408 W and this is the highest value measured during the study. In contrast to the flow rate of the heat during the day (36.1 ℃) only 3305.22 W, it was because at that time the average speed measured ambient air is very low at about 0.43 m/s.

In a state of normal weather without rain, the result of the heat is highest at night because of the value of a high speed to make the numeric value reynolds greatly increased even though the air temperature measured is low, as shown in the graph the value of the flow rate of calorific lowest to highest starting from the morning, afternoon, evening, and night. But things can change if the state of the wind in a state of calm where the wind does not have air motion that is felt in the field or in other words a very low wind speeds below 0.3 m/s.

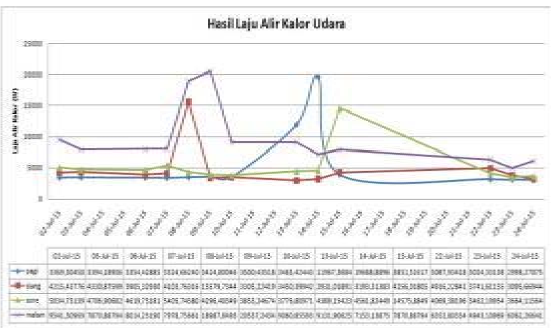

Figure4. heat flow rate of air

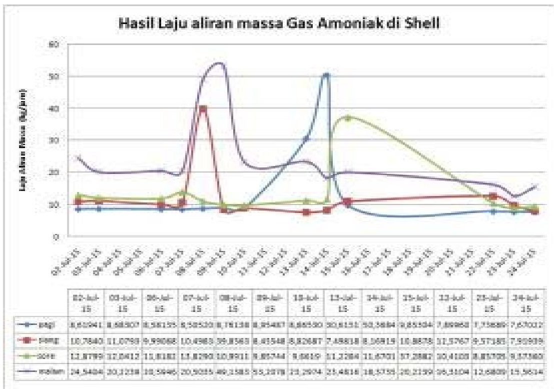

Figure 5. ammonia gas mass flow rate

The influence of air environment will provide additional heat to the shell surface area, thus the ammonia fluid as the fluid side of the shell will absorb heat from the surrounding air. The variation of temperature and air velocity will also Causes evaporated mass flow rate to be volatile due to the result of heat flow rate is not constant. From the analysis of the calculation of the value of the additional mass flow rate of air evaporated by the heat is in the range of 7.49 kg / h to 53.2 kg / hour. The amount of the evaporated mass flow rate is proportional to the calorific value obtained in which the value of λ amounted to 1407.22 kJ / kg.

The influence of the amount of the mass flow rate of ammonia is produced from synthesis gas are assumed to be influenced by environmental conditions surrounding air because of the tube in the location dimension are inside the shell and dissipates heat to the fluid ammonia shell, there is no influence only on the condition chiller that relies on heat transfer coefficient overalls and big actual fouling factor. When viewed from the effectiveness of the chiller itself that there is a decrease in the effectiveness of state net 55.46% to 23.43% at the limit permitted fouling factor and must be cleaned. In contrast to see the results of heat from the air in two states that assuming without fouling inside and outside surface of the shell, the heat received by ammonia is not decreased by more than 1% as shown in Table 4:22 therefore the influence of ambient air is maintained to the decline efektifias of chiller that own.

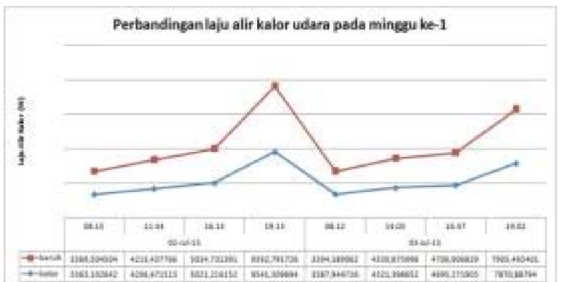

Figure 6. Comparison of heat flow rate of clean and dirty at week -1

Figure 7. Comparison of heat flow rate of clean and dirty at week -2

Figure 8. Comparison of heat flow rate of clean and dirty at week -3

Figure 9. Comparison of heat flow rate of clean and dirty at week -4

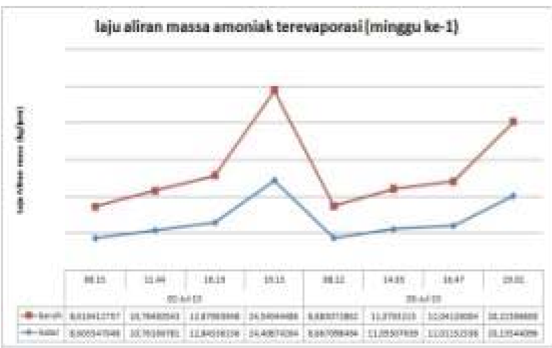

Figure 10. Comparison of the mass flow rate of the additional ammonia evaporated by week -1

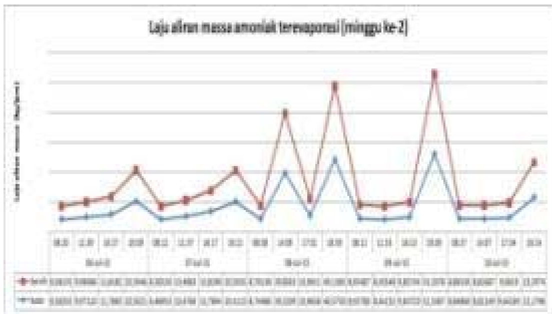

Figure 11. Comparison of the mass flow rate of the additional ammonia evaporated by week -2

Figure 12. Comparison of the mass flow rate of the additional ammonia evaporated by week -3

Figure 13. Comparison of the mass flow rate of the additional ammonia evaporated by week -4

4. CONCLUSION

1. The coefficient of heat transfer of air greatly affect the value of air velocity will change the value of the Reynolds number than the ambient temperature environment.
2. The calorific value of air flow rate and the mass flow rate of ammonia that evaporates high in chiller 3A-119C obtained from the rain and the current environmental conditions at night.
3. The rate of mass is evaporated due to the heat transfer air is not decreased by more than 1%

despite the effectiveness chiller decreased from 90.422% to 61.259% due to boundary conditions fouling factors shell and tube are allowed.

REFERENCES

1. Torralba, J.M., C.E. da Costa, and F. Velasco, *P/M aluminum matrix composites: an overview.* Journal of Materials Processing Technology, 2003. **133**(1–2): p. 203-206.
2. Chu, K.-T., et al., *Research of phase transformation induced biodegradable properties on hydroxyapatite and tricalcium phosphate based bioceramic.* Ceramics International, 2013. **39**(2): p. 1455-1462.
3. Mannschatz, A., A. Müller, and T. Moritz, *Influence of powder morphology on properties of ceramic injection moulding feedstocks.* Journal of the European Ceramic Society, 2011. **31**(14): p. 2551-2558.
4. Contreras, J.M., A. Jiménez-Morales, and J.M. Torralba, *Fabrication of bronze components by metal injection moulding using powders with different particle characteristics.* Journal of Materials Processing Technology, 2009. **209**(15–16): p. 5618-5625.
5. Sulong, A.B., A. Arifin, and Z. Harun, *Jig Prototype for Computer-Assisted Total Knee Replacement and Its Flow Simulation.* International Journal of Technology, 2016. **7**(1): p. 132.